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Wolcott et al.

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(54) **SCHEDULED TRANSMISSION OF DATA**

(71) Applicants: **Larry Wolcott**, Englewood, CO (US); **Kevin Johns**, Centennial, CO (US)

(72) Inventors: **Larry Wolcott**, Englewood, CO (US); **Kevin Johns**, Centennial, CO (US)

(73) Assignee: **Comcast Cable Communications, LLC**, Philadelphia, PA (US)

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H04L 12/825 (2013.01)

(52) **U.S. Cl.**
CPC ***H04L 47/12*** (2013.01); ***H04L 47/266*** (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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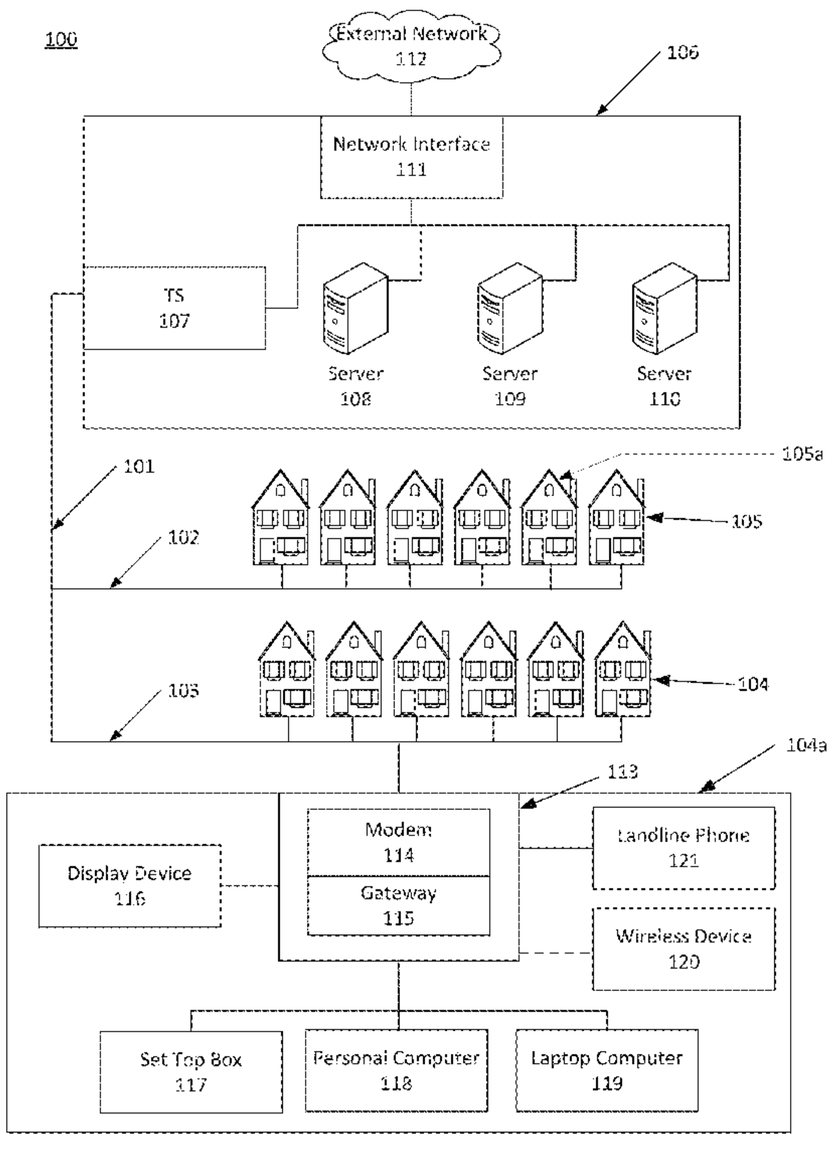
Primary Examiner — Ian N Moore
Assistant Examiner — Eric H Wang
(74) *Attorney, Agent, or Firm* — Banner & Witcoff, Ltd.

(57) **ABSTRACT**

A method and system may allow for the scheduling of transmissions. A device may send a transmission request over a network where the request may be an upload request or a download request. Traffic may be monitored on the network and the traffic may determine when the transmission is to be scheduled. Depending on the traffic and the type of transmission, the transmission may be scheduled for a future time or may be added to a queue of pending transmissions. Once commenced, the transmission may be paused and resumed based on continually monitored traffic on the network.

20 Claims, 8 Drawing Sheets



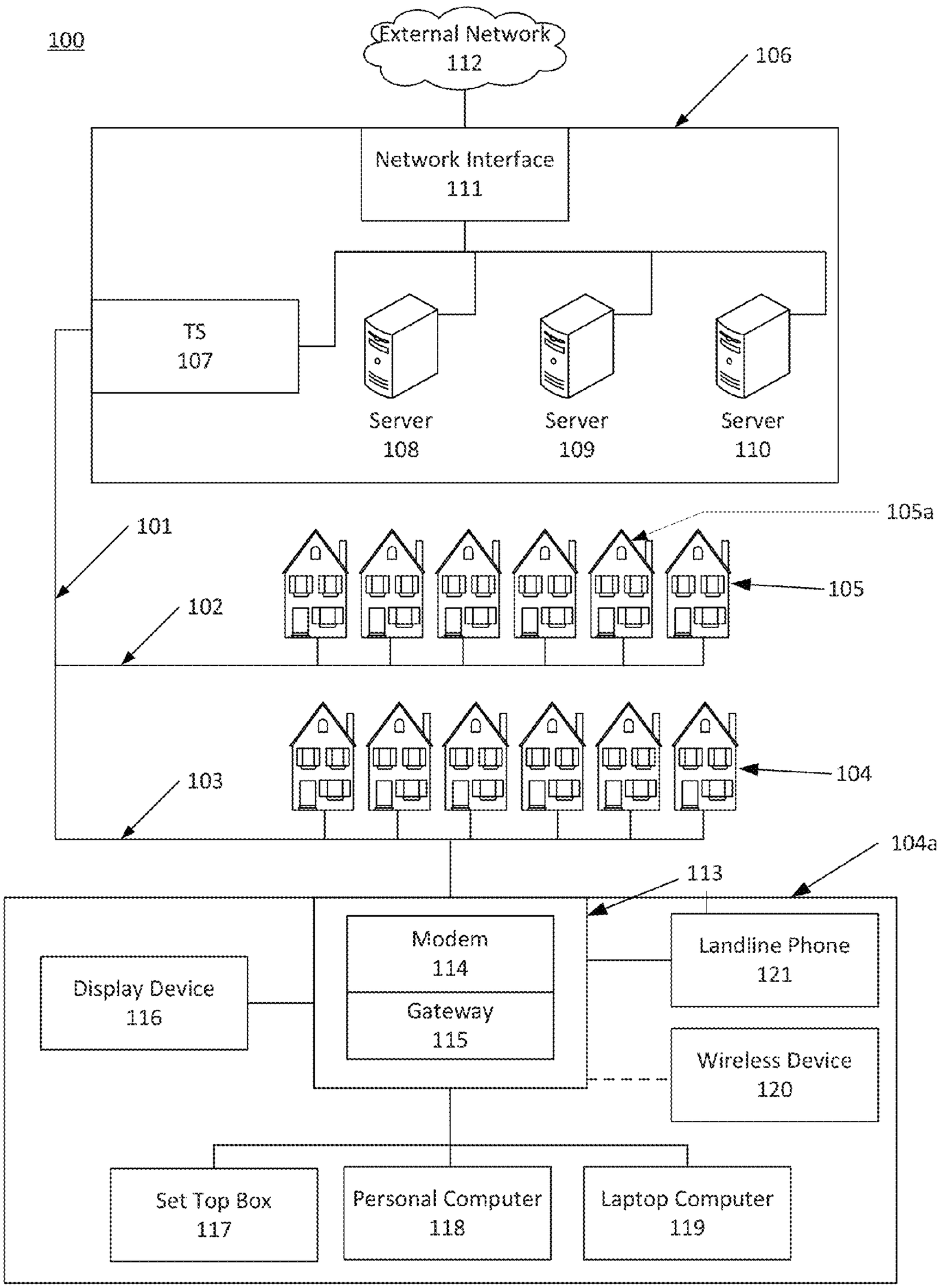

100
External Network
112
106
Network Interface
111
TS
107
Server
108
Server
109
Server
110
101
105a
102
105
103
104
104a
113
Modem
114
Gateway
115
Display Device
116
Landline Phone
121
Wireless Device
120
Set Top Box
117
Personal Computer
118
Laptop Computer
119

Fig. 1

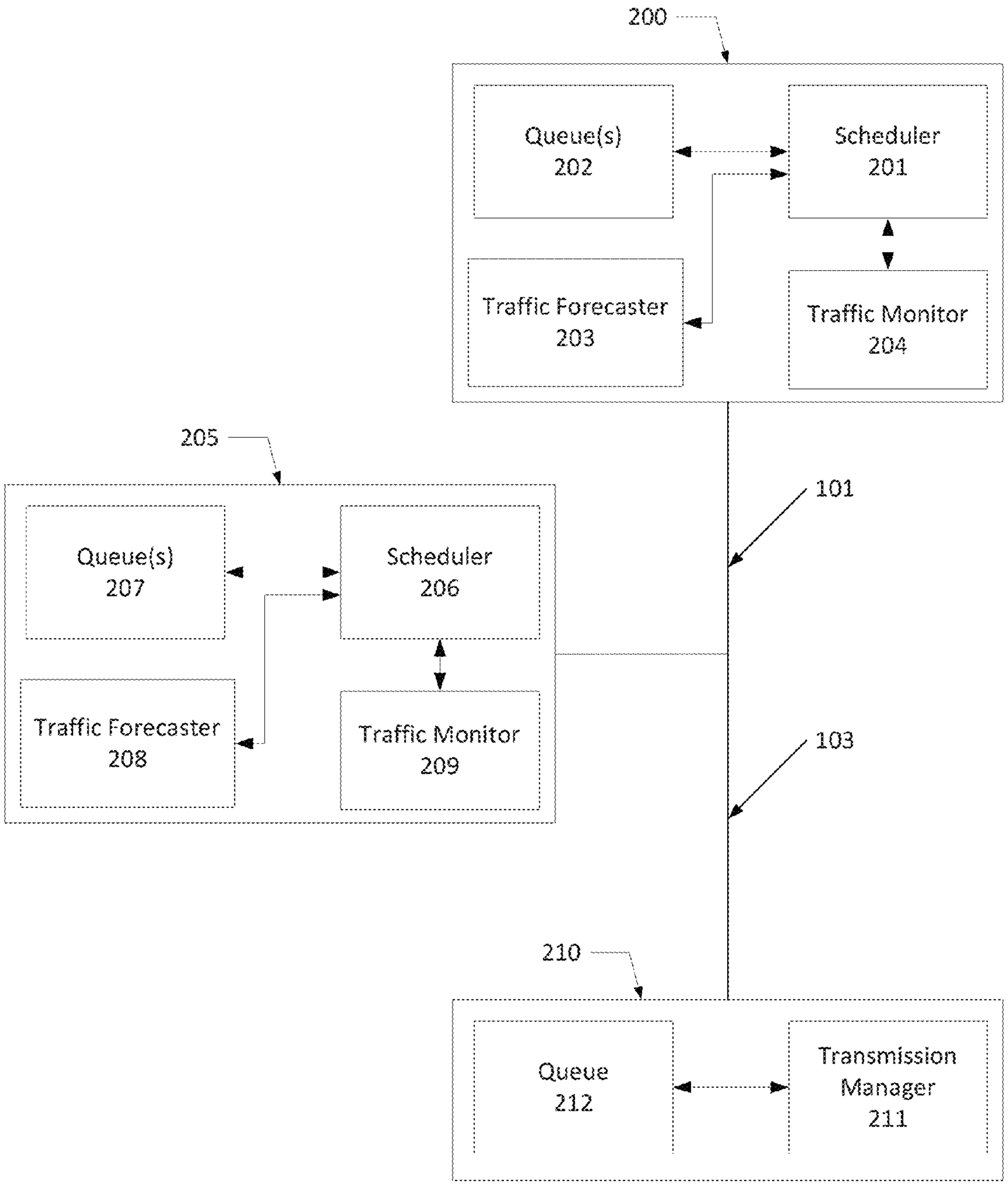

200
Queue(s)
202
Scheduler
201
Traffic Forecaster
203
Traffic Monitor
204
205
Queue(s)
207
Scheduler
206
Traffic Forecaster
208
Traffic Monitor
209
101
103
210
Queue
212
Transmission
Manager
211

Fig. 2

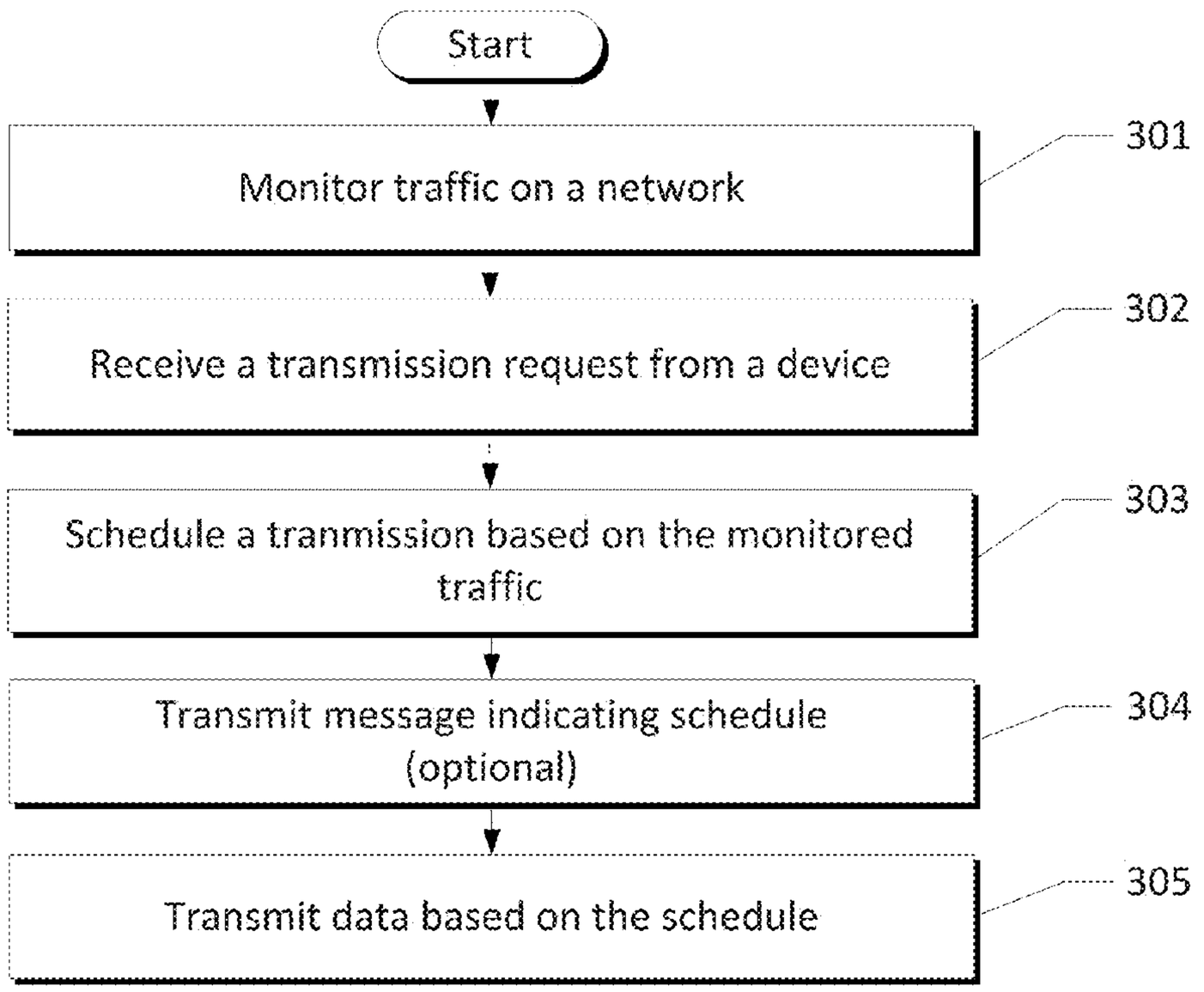

Start
Monitor traffic on a network
301
Receive a transmission request from a device
302
Schedule a tranmission based on the monitored traffic
303
Transmit message indicating schedule (optional)
304
Transmit data based on the schedule
305

Fig. 3

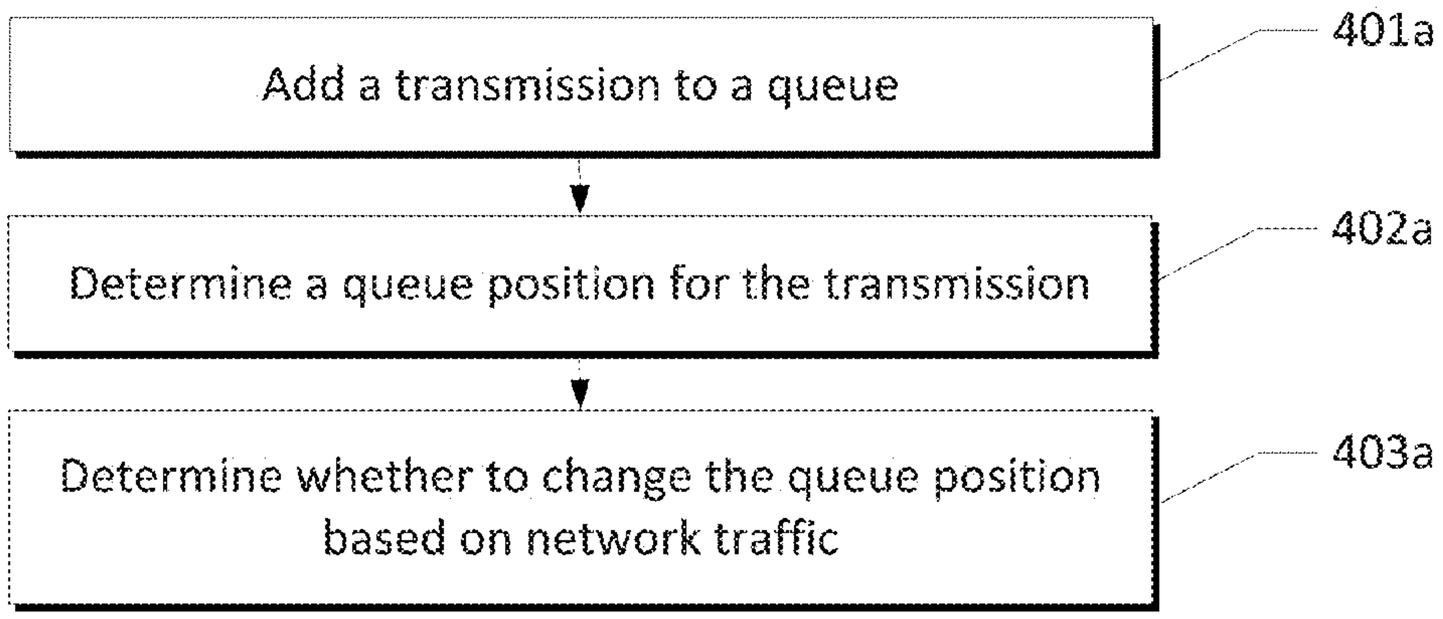

Add a transmission to a queue
401a
Determine a queue position for the transmission
402a
Determine whether to change the queue position based on network traffic
403a

Fig. 4a

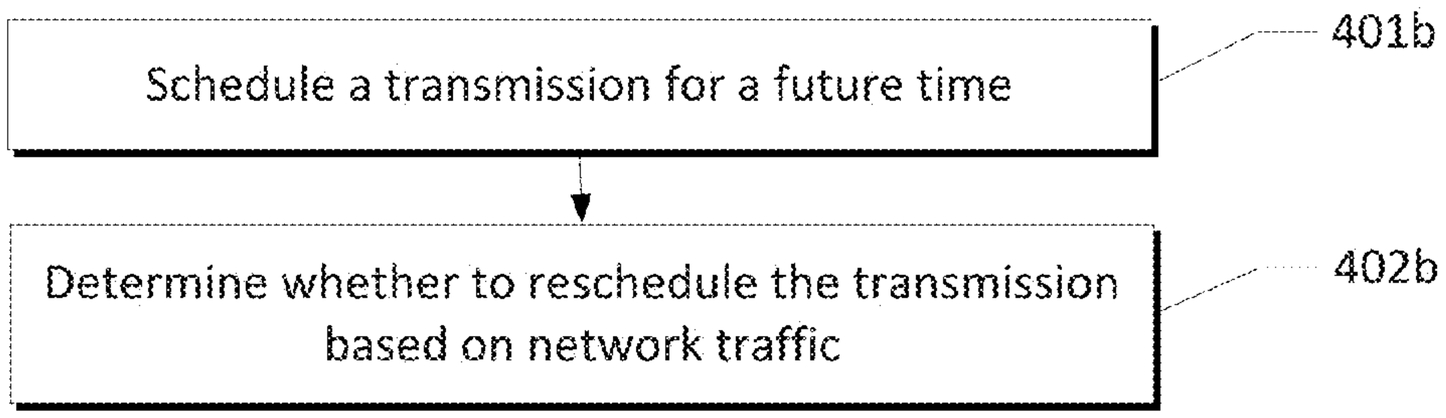

Schedule a transmission for a future time
401b
Determine whether to reschedule the transmission based on network traffic
402b

Fig. 4b

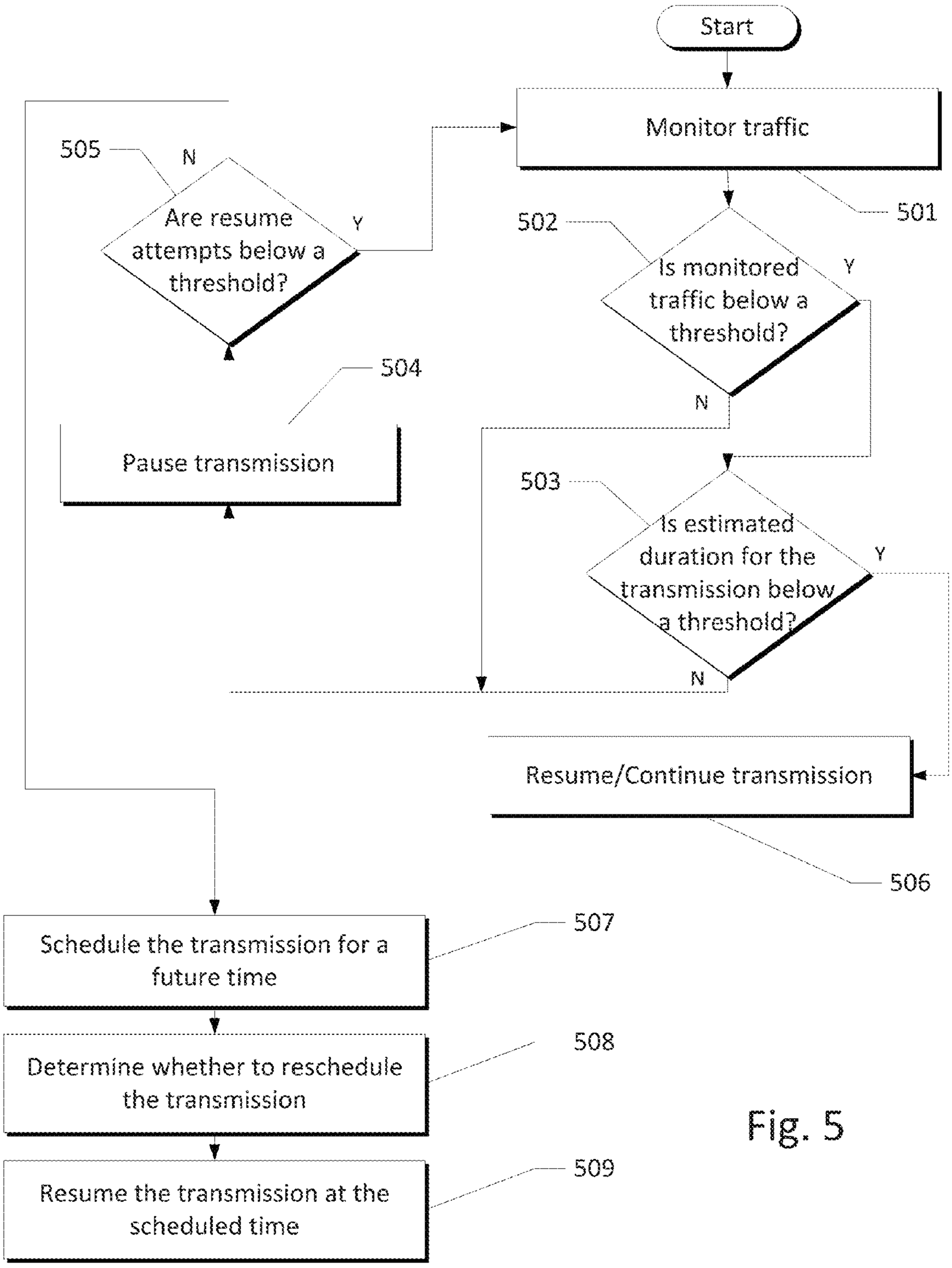

Start
Monitor traffic
501
502
Is monitored traffic below a threshold?
Y
N
503
Is estimated duration for the transmission below a threshold?
Y
N
504
Pause transmission
505
Are resume attempts below a threshold?
N
Y
Resume/Continue transmission
506
Schedule the transmission for a future time
507
Determine whether to reschedule the transmission
508
Resume the transmission at the scheduled time
509

Fig. 5

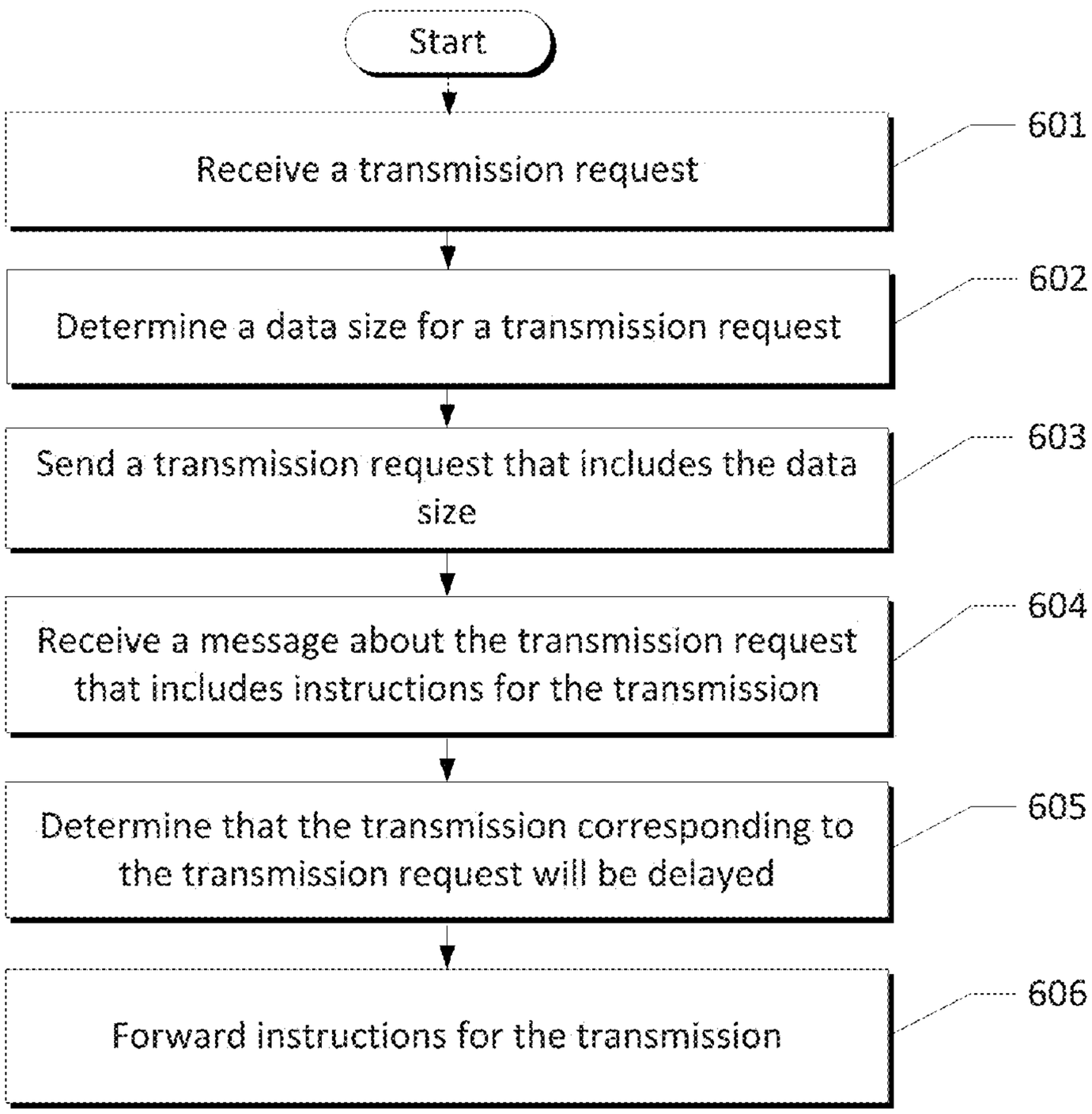

Start
Receive a transmission request
601
Determine a data size for a transmission request
602
Send a transmission request that includes the data size
603
Receive a message about the transmission request that includes instructions for the transmission
604
Determine that the transmission corresponding to the transmission request will be delayed
605
Forward instructions for the transmission
606

Fig. 6

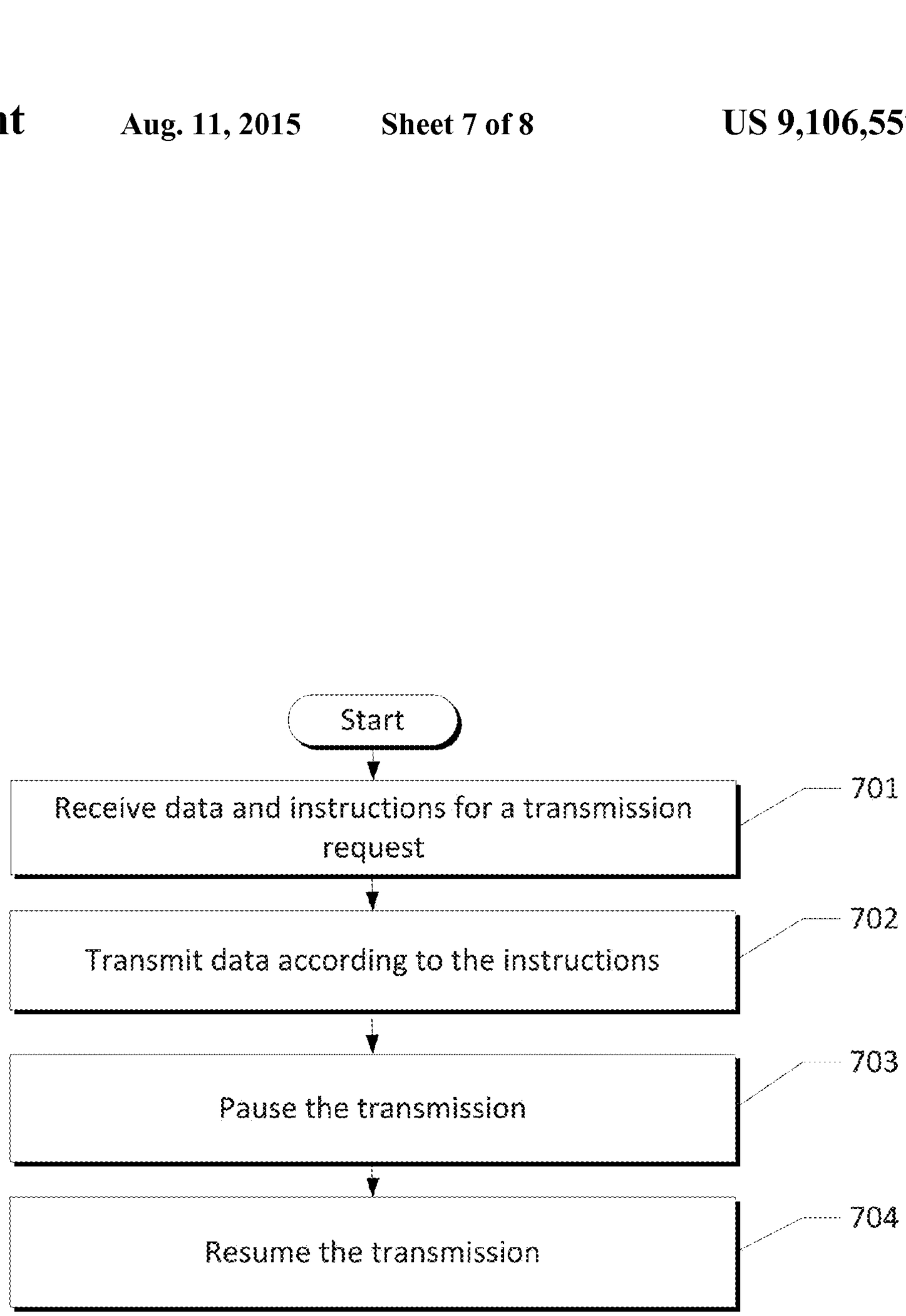

Start
Receive data and instructions for a transmission request
701
Transmit data according to the instructions
702
Pause the transmission
703
Resume the transmission
704

Fig. 7

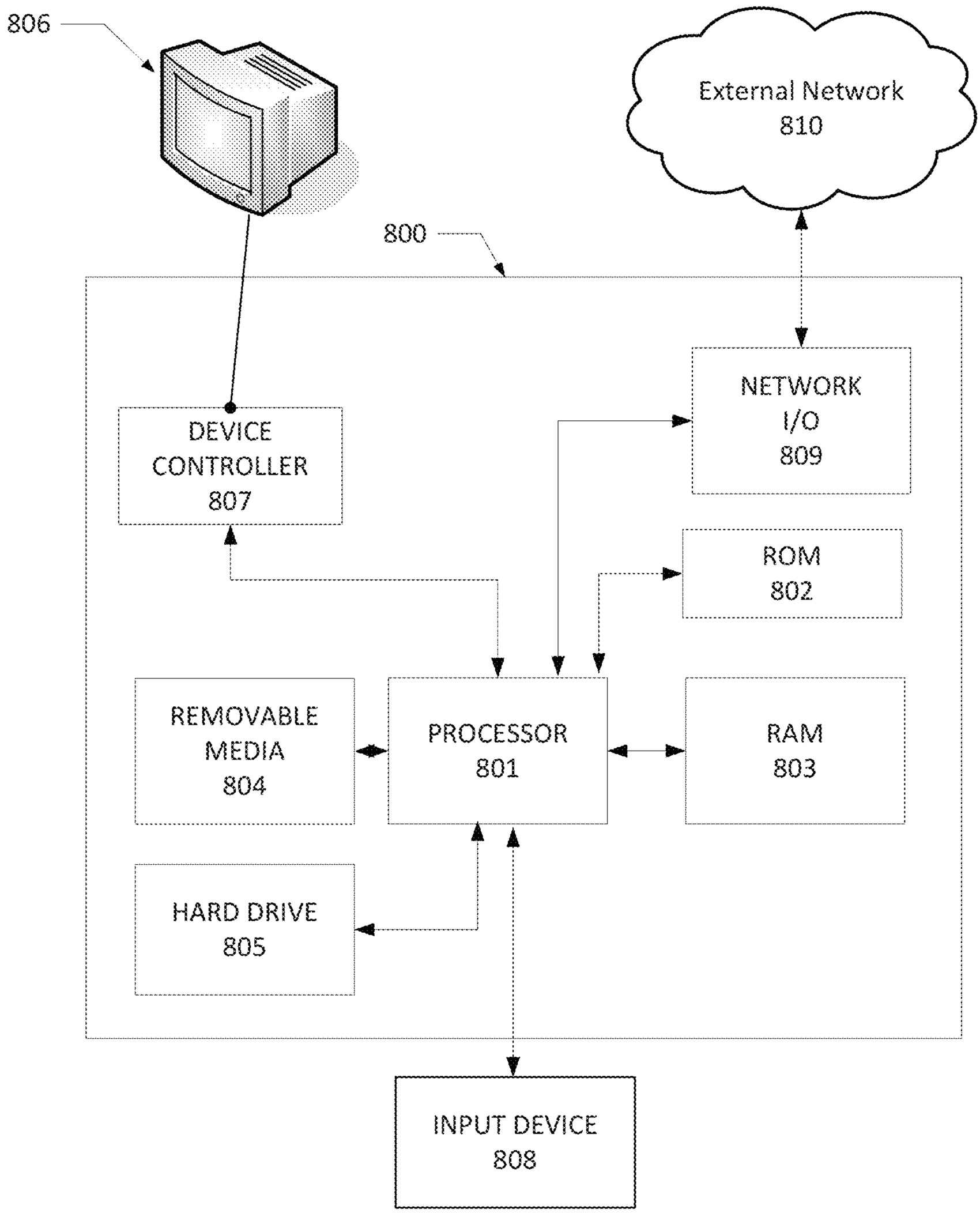

806
External Network
810
800
DEVICE
CONTROLLER
807
NETWORK
I/O
809
ROM
802
REMOVABLE
MEDIA
804
PROCESSOR
801
RAM
803
HARD DRIVE
805
INPUT DEVICE
808

FIG. 8

SCHEDULED TRANSMISSION OF DATA

BACKGROUND

Bandwidth is an important resource for modern networks. For example, traffic on a network can become heavily congested due to asymmetric bandwidth constraints that may limit upload capacity compared to download capacity. To lessen the negative effects of network congestion, improvements are needed in transmitting data.

SUMMARY

The following summary is for illustrative purposes only, and is not intended to limit or constrain the detailed description.

In some embodiments, a data transmission request may be received from a device, which may be a client. The request may be an upload request or a download request and may include a data size and other characteristics. An estimated duration for the transmission may be determined based on traffic monitored on a network. The transmission may be scheduled based on the monitored traffic and estimated duration.

In some embodiments, the data transmission may be scheduled by adding it to a queue of pending transmissions. A queue position for the transmission may be determined based on continually monitored traffic for the network and an estimated transmission duration.

In some embodiments, a data transmission may be scheduled for a future time based on an estimate that the network traffic will be low or lower at the future time. The estimate may be based on historical trends for traffic.

In some embodiments, a device, such as a client device, may send a data transmission request to a central office, such as a data processing facility, and receive, in response to the request, a message that indicates a schedule for the transmission. The message may include instructions on how to complete the transmission, including an allocated bandwidth for the transmission. The client device may forward instructions about the scheduled transmission, and in some embodiments data for the scheduled transmission, to a second device and the second device may complete the transmission.

BRIEF DESCRIPTION OF THE DRAWINGS

Aspects of the present disclosure are described by way of example with respect to the accompanying figures in which like numerals indicate similar elements.

FIG. **1** illustrates an example communication network according to one or more embodiments.

FIG. **2** illustrates a functional block diagram according to one or more embodiments.

FIG. **3** illustrates an example process for scheduling transmissions according to one or more embodiments.

FIGS. **4***a* & **4***b* illustrate example processes for adding a transmission to a queue and scheduling a transmission according to one or more embodiments.

FIG. **5** illustrates an example process for pausing and resuming a transmission according to one or more embodiments.

FIG. **6** illustrates an example process for requesting a transmission according to one or more embodiments.

FIG. **7** illustrates an example process for completing a requested transmission according to one or more embodiments.

FIG. **8** illustrates an example general computing device according to one or more embodiments.

DETAILED DESCRIPTION

In the following description, reference is made to the accompanying figures, in which are shown various illustrative embodiments. It is to be understood that other embodiments may be utilized and structural and functional modifications may be made, without departing from the scope of the present disclosure.

FIG. **1** illustrates an example communication network **100** on which many of the various features described herein may be implemented. Network **100** may be any type of information distribution network, such as satellite, telephone, cellular, wireless, etc., and combinations thereof. Various examples may include an optical fiber network, a coaxial cable network, or a hybrid fiber/coax distribution network. Such networks **100** may use a series of interconnected communication links **101-103** (e.g., coaxial cables, optical fibers, wireless, etc.) to connect multiple premises **104** and **105** (e.g., businesses, homes, consumer dwellings, etc.) to one or more central offices **106** (e.g., local offices or head ends). A central office **106** may exchange upstream/downstream information signals over the links **101-103**, with premises **104** and **105**. Each premise may have one or more terminals configured to transmit/receive and process those signals.

There may be one link **101** connected to the central office **106**, and it may be split a number of times, for instance, into links **102** and **103**, to distribute the signal to/from various premises **104** and **105** in the vicinity (which may be up to many miles) of the central office **106**. The links **101-103** may include components (not illustrated), such as splitters, filters, amplifiers, etc., to help convey the signals. Portions of the links **101-103** may be implemented with a combination of one or more of fiber-optic cable, coaxial cable, twisted shielded cable, wireless communication paths, or other signal carrying medium.

The central office **106** may include an interface, such as a termination system (TS) **107**. In various examples, the interface **107** may be a cable modem termination system (CMTS), which may be a computing device configured to manage communications between devices on the network of links **101-103** and backend devices such as servers **108-110** (to be discussed further below). The interface **107** may be as specified in a standard, such as the Data Over Cable Service Interface Specification (DOCSIS) standard, published by Cable Television Laboratories, Inc. (a.k.a. CableLabs), or it may be a similar or modified device instead. The interface **107** may be configured to place data on one or more downstream signals modulated at one or more predetermined frequencies to be received by network interface **113** (e.g., including modem **114**) at the various premises **104** and **105**, and to receive upstream signals modulated at one or more other predetermined frequencies from those terminals. While one network interface **113** is shown in premise **104***a*, each premise may include more than one terminal.

The central office **106** may also include one or more network interfaces **111**, which can permit the central office **106** to communicate with various other external networks **112**. These networks **112** may include, for example, networks of Internet devices, telephone networks, cellular telephone networks, fiber optic networks, local wireless networks (e.g., WiMAX), satellite networks, and any other network capable of carrying data to and from central office **106**. The network interfaces **111** may include the corresponding circuitry adapted to communicate on the external networks **112**, and to

other devices on the networks **112** (e.g., a cellular telephone network and its corresponding cell phones).

The central office **106** may also include one or more servers **108-110**. An application server **110** may be a computing device configured to offer any desired service, and may run various languages and operating systems (e.g., servlets and JSP pages running on Tomcat/MySQL, OSX, BSD, Ubuntu, Redhat, HTML5, JavaScript, AJAX and COMET). In some embodiments, an application server may be responsible for scheduling a transmission request received from devices at premises **104** and **105**. Although shown separately, the servers **108** to **110** may be combined. Servers **108-110** may include one or more processors and memory storing computer executable instructions that when executed cause the processors to perform the functions of the servers.

An example premises **104***a*, such as a home, may include a network interface **113**. The network interface **113** can include communication circuitry adapted to allow a device to communicate on one or more links **101-103** with other devices in the network. For example, the network interface **113** may include a modem **114**, which may include transmitters and receivers used to communicate on the links **101-103** and with the central office **106**. The modem **114** may be, for example, a coaxial cable modem (for coaxial cable lines **101-103**), a fiber interface node (for fiber optic lines **101-103**), twisted-pair telephone modem, cellular telephone transceiver, satellite transceiver, local Wi-Fi router or access point, or other modem device adapted to communicate over links **101-103**. Also, although only one modem is shown in FIG. **1**, a plurality of modems operating in parallel may be implemented within the network interface **113**.

Further, the network interface **113** may include a gateway **115**. The modem **114** may be connected to, or be a part of, the gateway **115**. The gateway **115** may be a computing device that communicates with the modem **114** to allow one or more other devices in the premises **104***a* to communicate with the central office **106** and other devices beyond the central office **106**. The gateway **115**, in various examples, may be a set-top box (STB), digital video recorder (DVR), computer server, or any other computing device. The gateway **115** may also include (not shown) local network interfaces to exchange communication signals with entities/devices/terminals in the premises **104***a*, such as display devices **116** (e.g., televisions), additional STBs **117**, personal computers **118**, laptop computers **119**, wireless devices **120** (e.g., wireless routers, wireless laptops, notebooks, tablets and netbooks, cordless phones (e.g., Digital Enhanced Cordless Telephone—DECT phones), mobile phones, mobile televisions, personal digital assistants (PDA), smartphones, etc.), landline phones **121** (e.g. Voice over Internet Protocol—VoIP phones), and any other desired devices. Examples of the local network interfaces include Multimedia Over Coax Alliance (MoCA) interfaces, Ethernet interfaces, universal serial bus (USB) interfaces, wireless interfaces (e.g., IEEE 802.11, IEEE 802.15), analog twisted pair interfaces, Bluetooth interfaces, and others. An example premise **105***a* may comprise a similar premise to **104***a*.

FIG. **2** illustrates a functional block diagram according to some embodiments. For example, computing device **200** may comprise scheduler **201**, one or more queues **202**, traffic forecaster **203**, and traffic monitor **204**. Computing device **200** may be located at local office **106** and may be implemented by one or more of servers **108-110** or TS **107**. Computing device **205** may comprise scheduler **206**, one or more queues **207**, traffic forecaster **208**, and traffic monitor **209**. Computing device **205** may be located somewhere along network branch **101** (e.g., where network link **101** connects with network link **103**). Computing device **210** may comprise transmission manager **211** and one or more queues **212**. Computing device **210** may be located at a client premises (e.g., premises **104**(*a*)) and may further be implemented by various elements at the client premises (e.g., interface **113**, set top box **117**, personal computer **118**, laptop computer **119**, wireless device **120**, etc.). In some embodiments, computing devices **200**, **205**, and **210** communicate with one another in order to schedule transmissions.

In computing device **200**, scheduler **201** may schedule transmissions (e.g., upload transmissions or download transmissions) by communicating with queue(s) **202**, traffic forecaster **203**, and traffic monitor **204**. One or more queue(s) **202** may comprise transmission queues and scheduler **201** may store delayed transmissions in queue(s) **202**. Traffic forecaster **203** may forecast network traffic (e.g., traffic on network links **101-103**) and scheduler **201** may schedule transmissions based on the forecasted traffic. Traffic monitor **204** may monitor network traffic (e.g., traffic on network links **101-103**) and scheduler **201** may schedule transmissions based on the monitored traffic.

In computing device **205**, scheduler **206**, queue(s) **207**, traffic forecaster **208**, and traffic monitor **209** may operate similarly to the elements of computing device **200**. In some embodiments, scheduler **206** may be responsible for scheduling transmissions for transmission requests from premises **104** on network link **103**. For example, queue(s) **207** may store transmissions for premises **104**, traffic forecaster **208** may forecast traffic on network link **103**, and traffic monitor **209** may monitor traffic on network link **103**. In some embodiments, the elements of computing device **205** communicate with the elements of computing device **200** in order to schedule transmissions for premises **104**.

In computing device **210**, transmission manager **211** may communicate with one or more of scheduler **206** and scheduler **201** to schedule transmissions for a client premises (e.g., premises **104**(*a*)). Queue **212** may store delayed transmission for the premises and may further communicate with one or more of schedulers **201** and **206**. Transmission manager **211** may be implemented across various computing devices at the premises (e.g., interface **113**, set top box **117**, personal computer **118**, laptop computer **119**, wireless device **120**, etc.). For instance, transmission manager **211** may be a distributed application running on a plurality of computing devices. In some embodiments, one or more of computing devices **200**, **205**, and **210** may be omitted and/or one or more of the elements within computing devices **200**, **205**, and **210** may be omitted.

An example process of scheduling transmissions is described further below in FIGS. **3-5**, with reference to FIGS. **1** and **2**. In an illustrative example, central office **106** may schedule transmissions corresponding to transmission requests generated at premises **104** and **105**. In some embodiments, a transmission request may be generated by a client/terminal, such as by gateway **115**, display device **116**, Set Top Box **117**, personal computer **118**, laptop computer **119**, or wireless device **120**, or other device within a premises (e.g., premises **104***a*). This request may be received by transmission manager **211**. The request may be sent over the network links **101** and **103** to central office **106**, and server **110** at central office **106** may implement the process of FIGS. **3-5** to schedule a transmission for the request. For example, transmission manager **211** may send the request to scheduler **201** which may schedule a transmission for the request. In some embodiments, the scheduling process illustrated in FIGS. **3-5** may be implemented at various other points on network links **101-103** by various other servers or computing devices. For

example, transmission manager **211** may send the request to scheduler **206** which may schedule a transmission for the request. In some embodiments, scheduler **206** communicates with scheduler **201** to schedule the transmission.

In an illustrative example, a transmission may comprise a client/terminal sending data across a network to a computing device (e.g., uploading a picture to a server) or a client/terminal receiving data sent from a computing device across a network (e.g., downloading a video file from a peer). In some embodiments, the computing device on the other end of the transmission (e.g., sending data to the client/terminal or receiving data from the client/terminal) may comprise a server (e.g., client server system), a client/terminal (e.g., peer-to-peer system), or any other computing device capable of transmitting data.

As illustrated in FIG. **3**, the process of scheduling a transmission may begin in step **301** with monitoring traffic on a network. For example, one or more of traffic monitor **204** or traffic monitor **209** may monitor traffic (e.g., Internet Protocol (IP) data packets, Transmission Control Protocol (TCP)/IP data packets, User Datagram Protocol (UDP) data packets, cellular data packets, etc.) on network links **101**-**103**. In some embodiments, the traffic at network link **102** is monitored separately from the traffic on network link **103**. That is, premises **104** on network link **103** may have low network usage and network link **103** may therefore experience low traffic while premises **105** on network link **102** may have heavy network usage and network link **102** may experience high traffic.

In some embodiments, the transmission request being scheduled may comprise a download request (e.g., to receive data at the client/terminal) or an upload request (e.g., to send data from the client/terminal). In further embodiments, an upload request may be a delay-eligible upload request indicating that the requested upload does not need to be performed immediately. For example, a client may request to upload a large picture or video onto a server that operates a social networking website and the client may indicate in the upload request that it is a candidate to be scheduled for a future time. This may be accomplished using software resident on a client/terminal system (e.g., transmission manager **211**) that indicates a request is a delay-eligible upload request.

In some embodiments, a limited amount of bandwidth may be allocated within the network for downloads, uploads, delay-eligible uploads, or a combination of these. In an illustrative example, monitoring traffic may include monitoring the traffic of downloads, uploads, delay-eligible uploads, or a combination these.

In step **302**, a transmission request is received from a client/terminal. For example, the request may be received at scheduler **206** or scheduler **201**. The transmission request may include a data size for the data requested to be transmitted. In some embodiments, the transmission request may comprise a download, upload, or delay-eligible upload request.

In step **303**, a transmission corresponding to the request is scheduled based on the monitored traffic. For example, based on the monitored traffic being above a threshold, scheduler **201** or scheduler **206** may schedule the transmission for a future time or may add the transmission to a queue of pending transmissions. In some embodiments, the transmission is scheduled based on an estimated duration and/or file size for the transmission. For example, a request may be received from premises **105***a* on network link **102**. The request may indicate a data size for the data requested to be transmitted. Based on the monitored traffic on network links **101**, **102**, and/or **103**, an estimated duration may be determined for a transmission corresponding to the request. Based on the estimated duration being above a threshold, the transmission may be scheduled for a future time or may be added to a queue of pending transmissions.

In some embodiments, the request from a premises (e.g., premises **105***a*) may comprise a download request, an upload request, or a delay-eligible upload request and the traffic being monitored may be download traffic, upload traffic, or a combination of these. Based on monitored traffic on network links **101**, **102**, and/or **103**, a transmission for the request may be scheduled for a future time or the transmission may be added to a queue of pending transmissions. In some embodiments, only the traffic for the type of transmission requested (e.g., upload or download) is used to determine a scheduling for the transmission. For example, for an upload request, upload traffic may be monitored to determine a scheduling for the upload transmission. In some embodiments, all traffic is monitored and is used to determine a scheduling for a transmission regardless of transmission type, direction, etc.

In some embodiments, metrics of traffic flow are calculated based on the monitored traffic. The metrics may indicate, for example, the volume of data traffic. The volume of data traffic metrics may include, in various examples, measurements of total data transfer over the period, peak instantaneous data rate within the period, average data rate over the period, and combinations thereof. The measurements may include upload data, download data, and/or combinations thereof. In some embodiments, if it is determined that one or more of the calculated metrics (e.g., traffic volume) exceeds (is above or below) a threshold, a transmission may be scheduled for a future time or may be added to a queue of pending transmissions.

In some embodiments, traffic at different points in the network may be used to determine scheduling for a transmission. For example, data transmitted from premises **105***a* passes over network links **101** and **102** to arrive at central office **106**. Accordingly, traffic over network links **101** and **102** may be used to determine scheduling for a transmission from premises **105***a*. In another example, data transmitted from premises **104***a* passes over network links **101** and **103** to arrive at central office **106**. Accordingly, traffic over network links **101** and **103** may be used to determine scheduling for a transmission from premises **104***a*. In some embodiments, traffic monitor **204** may monitor traffic on network link **101** and traffic monitor **209** may monitor traffic on network link **103**.

In some embodiments, a message is sent to the requesting client/terminal that indicates a schedule for the transmission. The message may indicate that the transmission has been scheduled for a future time or that the transmission has been added to a queue of pending transmissions. For example, scheduler **201** may send a message to transmission manager **211**.

In some embodiments, the scheduled transmission may be allocated a bandwidth within the network. For example, the bandwidth may be less than the default bandwidth for a transmission. For instance, the scheduled transmission may be an upload transmission and the allocated bandwidth for the scheduled upload transmission may be less than the default bandwidth for an upload transmission. For example, the network may be configured according to one or more DOCSIS standards, and the bandwidth allocated for the upload transmission may be less than the default bandwidth for an upload transmission in the DOCSIS standard. In some embodiments, a message sent to the client indicating a scheduling for the transmission includes various data related to the transmis-

sion, such as an allocated bandwidth for the transmission, a scheduled time for the transmission, an estimated duration time for the transmission, an estimated wait time for commencing the transmission, etc.

In some embodiments, software resident on a client/terminal (e.g., transmission manager **211**) may indicate that a transmission request is a delay-eligible request. Based on this indication, a scheduler (e.g., scheduler **201**) may determine that the transmission corresponding to the request should be delayed without considering traffic and/or estimated transmission duration. Accordingly, a transmission request that is indicated as a delay-eligible transmission request may be determined to be delayed by a scheduler without determining traffic is above a threshold and/or without determining an estimated duration for the transmission is above a threshold. The delay-eligible upload may be scheduled for a future time or may be added to a queue of transmissions.

In some embodiments, step **303** of FIG. **3** further comprises some or all of the steps of FIG. **4***a*. For example, a scheduled transmission may be added to a transmission queue, as in step **401***a*. The queue may contain delayed transmissions. For example, based on monitored traffic being above a threshold, a transmission may be delayed for a period of time (e.g., based on a queue position for the transmission). The queue may have a defined order (e.g., sequential, interleaved, etc.). In some embodiments, the transmission queue follows a First In First Out (FIFO) priority. In some embodiments, the position for transmissions within the transmission queue may be based on monitored traffic for the client/terminal that is requesting a transmission, predicted traffic (e.g., at predetermined times) for the client/terminal that is requesting a transmission, an estimated duration for a transmission based on the data size, a relative priority for a transmission, or a combination of these. In some embodiments, the queue may comprise a comparable data structure (e.g., stack, etc.).

In some embodiments, the queue is stored in a database. The queue may comprise a queue of pointers and each pointer may point to a transmission (e.g., download, upload, or delay-eligible upload transmission). In another example, the queue may comprise a queue of transmissions (e.g. physical data that represents a download, upload, or delay-eligible upload transmission). The queue may comprise a download queue, and a download transmission corresponding to a download request (e.g., pointer or physical data) may be added to the download queue. In another example, the queue may comprise an upload queue, and an upload transmission corresponding to an upload request (e.g., pointer or physical data) may be added to the upload queue. In a further example, the upload queue may further comprise a delay-eligible upload queue. In some embodiments, if a transmission is added to a transmission queue, a message is sent to the requesting client/terminal indicating that the transmission has been added to the queue.

In some embodiments, the queue may comprise one or more queues that may be located at central office **106** or at another computing device on network links **101**, **102**, or **103**. For example, the queue may comprise one or more of queues **202** and **207**. In some embodiments, a computing device (e.g., computing device **205**) may be located at the connection where network link **101** connects with network link **102** and the connection where network link **101** connects with network link **103**. In each computing device, one or more queue(s) (e.g., queue **207**) may queue transmissions for the respective network link (e.g., network link **102** or network link **103**). For example, a computing device that includes one or more queues located at the connection between network link **101** and network link **102** may queue transmissions for premises **105**. Similarly, a computing device that includes one or more queues located at the connection between network link **101** and network link **103** may queue transmissions for premises **104**.

In step **402***a*, a position may be determined in the transmission queue for the added transmission. In some embodiments, the position may be determined based on monitored traffic for the client/terminal that is requesting the transmission, predicted traffic (e.g., at predetermined times) for the client/terminal that is requesting the transmission, an estimated duration for the transmission based on the data size, a relative priority for the transmission, or a combination of these. For example, a first transmission may be requested by a client/terminal in premises **104***a* on network link **103** and a second transmission may be requested by a client/terminal in premises **105***a* on network link **102**. The monitored traffic on network link **103** may be light but the monitored traffic on network link **102** may be heavy. Because of this, an estimated duration for the first transmission may be less than an estimated duration for the second transmission. In this example, a determined position for the first transmission may be higher in priority (e.g., positioned higher in the queue) than a determined position for the second transmission based on the monitored traffic for the network links **103** and **102** and based on the estimated durations for the first transmission and the second transmission.

In step **403***a*, it is determined whether a queue position for a queued transmission should be changed based on the monitored traffic. For the above example, after a period of time, if the traffic on network link **103** increases (e.g., increases in volume) and the traffic on network link **102** decreases (e.g., decreases in volume), the estimated durations for first and second transmissions may change. If the change in traffic alters the estimated durations such that the new estimated duration for the second transmission is less than the new estimated duration for the first transmission, then the determined position for the second transmission may change to a higher priority (e.g., positioned higher in the queue) than the determined position for the first transmission.

In some embodiments, step **303** of FIG. **3** further comprises one or more of the steps of FIG. **4***b*. In an illustrative example, a transmission may be scheduled for a future time, as in step **401***b*. In some embodiments, the future time for the scheduled transmission may be based on estimated network traffic at the future time. For example, historical trends may be analyzed to forecast network traffic during various points in time. Traffic forecaster **203** and traffic forecaster **208** may forecast traffic on their respective network links. For example, traffic forecaster **203** may forecast traffic on network link **101** and traffic forecaster **208** may forecast traffic on network link **103**. Network link **102** may also have a traffic forecaster (not depicted) or one or more of traffic forecaster **203** and/or traffic forecaster **208** may forecast traffic on network link **102**. In some embodiments, traffic forecaster **203** forecasts traffic for all of network links **101-103**. The one or more traffic forecasters may be connected to one or more databases that store historical traffic data about the network (e.g., type of traffic (upload or download traffic), time of day, congestion, etc.). In some embodiments, the estimated traffic at the future time is based on a time of day for the future time, a day of week for the future time, whether the future time occurs on a weekday, whether the future time occurs on a weekend, whether the future time occurs on a holiday, or any combination thereof. For example, a transmission may be requested at 3:00 pm on a Tuesday afternoon but may be scheduled for 2:00 am on the following Wednesday morning because historical trends show that network traffic at 2:00 am

on Wednesday mornings is low. In some embodiments, the estimated traffic at the future time is determined to be less than the monitored traffic.

In step **402***b*, it is determined whether the scheduled future time for the transmission should be rescheduled based on the monitored traffic. In an illustrative example, if a transmission is scheduled for a future time because it was estimated that the future time would have low traffic, but at that future time, or a predetermined amount of time away from the future time, the monitored traffic is determined to be above a predetermined threshold, the transmission may be rescheduled to a new future time estimated to have low traffic (e.g., by one or more of traffic forecasters **208** and **203**). In some embodiments, when a transmission is rescheduled a message may be sent to the requesting client/terminal indicating the rescheduled future time for the transmission.

In some embodiments, step **303** of FIG. **3** includes scheduling a transmission based on premises information. For example, a transmission request may be received from premises **104**(*a*). Premises information may be stored about premises **104**(*a*) in a database located at central office **106**, at some other location on network links **101-103**, or at any other suitable location. The premises information may include a service type (e.g., service package), a transmission history, and other suitable information about premises **104**(*a*). A service type may define a service tier for the premises (e.g., premium, etc.) and may include a predetermined number of immediate transmissions for the premises depending on transmission type (e.g. upload transmission or download transmission) and size (e.g., above or below a predetermined threshold). For example, a premises in a premium service tier may be allotted five immediate upload transmissions per month that are above a predetermined size threshold. A transmission history may log previous transmissions for the premises. For example, a transmission history for a premises may log the number of immediate transmissions for the current month and for a predetermined number of previous months. The transmission history may also log the number of transmissions, the size of the transmissions, the type of the transmission (e.g., upload transmission or download transmission), a time of day for each transmission, etc.

In an example, premises **104**(*a*) may request an upload transmission of a certain size. Based on monitored traffic and/or an estimated duration for the transmission being above a threshold, a scheduler (e.g., scheduler **201**) may determine that the upload transmission should be delayed. Based on this decision, the service type may be checked to determine premises **104**(*a*)'s allotment of immediate upload transmissions of the requested size (e.g., per month) and the transmission history may be checked to determine the previous number of immediate upload transmissions for premises **104**(*a*) (e.g., for the current month). If premises **104**(*a*) is above the allotment for immediate upload transmission of the requested size, the upload transmission may be delayed (e.g., scheduled for a future time or placed in a queue). If premises **104**(*a*) is below the allotment for immediate upload transmissions of the requested size, a scheduler (e.g., scheduler **201**) may allow the upload transmission to immediately begin transmitting (e.g., not delay the transmission).

In some embodiments, a service tier may additionally include a predetermined number of rushed transmissions (e.g., within 1 hour, within 2 hours, etc.) and a transmission history may log the number of rushed transmissions for a premises. For example, a premises may request an upload transmission, and a scheduler may determine that the transmission should be delayed, as further detailed above. If the premises is below the allotment for rushed transmissions (e.g., based on the service type and transmission history), a scheduler may schedule the transmission within a rushed time window (e.g., within 1 hour, within 2 hours, etc.).

In some embodiments, the transmission history may log the number of delay-eligible transmissions (e.g., including size, type (upload transmission or download transmission), a time of day, etc.) for a premises. Based on the number of delay-eligible transmissions being above a threshold, a premises may receive incentives. For example, if a premises transmits an upload transmission above a threshold size as a delay-eligible upload, the premises may gain an extra immediate transmission allotment for an upload transmission of that size. The incentive may also include a discount on a bill, other monetary incentives, or any other suitable incentive.

In some embodiments, step **303** of FIG. **3** proceeds to step **304** (optional) where a message is transmitted indicating a schedule for the transmission. For example, a message may be sent to the requesting client/terminal that indicates a scheduled future time for the requested transmission or that indicates the transmission has been added to a queue. Where a scheduled future time is indicated in a message, the scheduled future time may be valid upon receipt of the message and the client/terminal may begin transmitting data at the scheduled future time. In another example, the scheduled future time is not valid upon receipt of the message and the client may not begin transmitting data at the scheduled future time until a second message (e.g., granting message) is sent to the client/terminal. In some embodiments, when a transmission is rescheduled for a new future time, a message may be sent to the requesting client/terminal indicating the new schedule for the transmission.

The process of FIG. **3** may proceed to step **305**, where the data is transmitted based on the schedule. In some embodiments, the data may be transmitted based on the transmission reaching the front (e.g., highest in priority) of a transmission queue or based on detecting that the scheduled time for the transmission is occurring, has occurred, or will occur within a predetermined amount of time.

In an illustrative example, a queued transmission reaching the front of a queue may be transmitted based on a monitored traffic being below a threshold, a duration for the transmission being below a threshold, or a combination of these. In an illustrative example, once permission is granted to a queued transmission, the queue may be updated by removing the transmission from the queue.

In an example, transmitting the data based on the schedule may include sending a granting message to the requesting client/terminal that grants permission to transmit the data. In some embodiments, the message may include instructions about an allocated bandwidth for the transmission. For example, the allocated bandwidth may be less than a default bandwidth for a transmission. The transmission may be a download transmission and the allocated bandwidth may be less than the default bandwidth for a download transmission. For instance, the network may be configured according to one or more DOCSIS standards, and the bandwidth for the download transmission may be less than the default bandwidth for a download transmission in the DOCSIS standard. In some embodiments, the transmission may be an upload transmission and the allocated bandwidth may be less than the default bandwidth for an upload transmission. For instance, the network may be configured according to one or more DOCSIS standards, and the bandwidth for the upload transmission may be less than the default bandwidth for an upload transmission in the DOCSIS standard.

In some embodiments, after the data begins to be transmitted, the process of scheduling a client transmission may move

to step **501** of FIG. **5**. In step **501**, traffic may continue to be monitored on the network (e.g. by traffic monitor **204**). The monitored traffic may comprise traffic on the network path between a central office **106** and the transmitting premises, traffic for a particular type of transmission (e.g., upload traffic, download traffic, or both), or a combination of these.

From step **501**, the process may move to step **502**, where it is determined whether the monitored traffic is below a threshold. If the monitored traffic is below the threshold (e.g., total data transfer is greater than a maximum limit), the process moves to step **504**. If the monitored traffic is below a threshold, the process moves to step **503**, where it is determined whether an estimated duration for the transmission is below a threshold. The estimated duration may be based on the partially completed transmission (e.g., un-transmitted portion of the transmission) rather than the entire transmission. The estimate can be determined similar to previously described estimates for transmission durations (e.g., based on traffic on the network between central office **106** and the transmitting premises, a data size for the partially completed transmission, an average data rate available for the transmission, etc.). If the estimated duration for the transmission is determined to be below a threshold, the process moves to step **506**. If the estimated duration is not determined to be below a threshold, the process moves to step **504**.

At step **504**, the transmission may be paused. In some embodiments, the paused transmission is marked as partially completed. For example, the marking may be stored in memory and may indicate the percentage of data that has been transmitted prior to the pause. The marking may be used to resume the transmission from the partially completed state rather than restart the transmission. In an illustrative example, the transmission may be paused by sending a message to the client/terminal with instructions to pause the transmission. Steps **501-505** may be performed multiple times (e.g., as a loop), based on the outcome of step **502** and step **503**. At step **504**, a transmission that has already been paused, and marked in some embodiments, may continue to be paused.

In some embodiments, the process may move from step **504** to step **505**, where the number of attempts (e.g., loops executed from steps **501-505**) is compared to a threshold. For example, the number of attempts may be stored in memory. If the number of attempts are below a threshold, the process may move back to step **501**. In some embodiments, the process may remain at step **501** for a period of time (e.g., a predetermined period of time) before attempting to resume the paused transmission by progressing to step **502**.

At step **506**, the paused, and in some embodiments marked, transmission is resumed. In an illustrative example, the paused transmission may be resumed from the partially completed portion (e.g., resumed from the non-transmitted portion). The paused transmission may be resumed from the partially completed portion based on a marking for the paused transmission, where the marking indicates the portion of the transmission that has been previously transmitted. In some iterations a transmission may be un-paused (e.g., actively transmitting) at step **506** and, in an illustrative example, the un-paused transmission may continue to transmit at step **506**.

In some embodiments, at step **505**, if the number of attempts is not below a threshold, the process may move to step **507**, where the paused transmission is scheduled for a future time. Scheduling a transmission for a future time may include the various embodiments described for scheduling a transmission for a future time (e.g., estimating traffic for the future time based on historical trends, etc.). After the scheduling is completed, the process may move to step **508** where, at a predetermined duration prior to the scheduled time, it is determined whether the scheduled time should be rescheduled based on monitored traffic. For example, if a transmission is scheduled for a future time because it was estimated that the future time would have low traffic, but at or near that future time (e.g., a predetermined proximity to the future time) the traffic is monitored to be greater than a predetermined threshold, the transmission may be rescheduled to a new future time estimated to have low traffic. If, in step **508**, it is determined that the transmission should not be rescheduled, the process moves to step **509**, where the paused transmission is resumed at the scheduled time. In some embodiments, the transmission may be resumed by sending a message to the client with instructions to resume the transmission. The paused transmission may be resumed as described in various embodiments (e.g., resuming the paused transmission based on a marking, etc.). The steps **502-509** of FIG. **5** may be performed by a scheduler (e.g., scheduler **201**).

While FIG. **5** illustrates a check where both the monitored traffic is be below a threshold (e.g., step **502**) and the estimated duration for the transmission is be below a threshold (e.g., step **503**) in order for the paused transmission to be resumed, this is only an example, and in some embodiments only one of these two values need be below a threshold to resume the paused transmission (e.g., progress to step **506**). More generally, some of the steps in FIG. **5** may be omitted or rearranged.

An embodiment of a process of transmitting scheduled transmissions is described further below in FIGS. **6-7**, with reference to FIGS. **1** and **2**. In an illustrative example, central office **106** (e.g., scheduler **201**) may schedule transmissions corresponding to transmission requests sent from premises **104** and **105**. In some embodiments, a request for transmission may be sent from premises **104***a* (e.g., from transmission manager **211**) by gateway **115**, display device **116**, Set top box **117**, personal computer **118**, laptop computer **119**, or wireless device **120**. The request may be sent over the network links **101** and **103** to central office **106**, and server **110** at central office **106** may schedule a transmission for the request.

In some embodiments, the transmission process illustrated in FIGS. **6-7** may include multiple elements at premises **104***a*. In an illustrative example, laptop **119** may generate a transmission request that is sent to modem **114** and further routed to central office **106** over network links **101** and **103**. After communicating with central office **106**, laptop **119** may forward instructions corresponding to the transmission request to network interface **113**, and network interface **113** may then communicate with central office **106** and complete the transmission. After communicating with central office **106**, laptop **119** may forward instructions to any of network interface **113**, including modem **114** and gateway **115**, or set top box **117**, and the element receiving the data may be configured to complete the transmission. For example, laptop **119** and the receiving network element may both be connected to a network (e.g., LAN, WLAN, etc.) that includes modem **114** and laptop **119** may forward the instructions to the receiving network element over the network. In some embodiments, after forwarding the instructions, laptop **119** may disconnect from the network and the receiving network element may complete the transmission. Accordingly, after forwarding instructions to the receiving network element, laptop **119** may sever all network connections with local office **106** or any other computing device used to schedule the transmission, and the receiving network element may complete the transmission.

As illustrated in FIG. **6**, in an embodiment, the process of forwarding a scheduled transmission may begin in step **601**

with receiving a transmission request. For example, a transmission request may be generated at laptop **119** and may be received by a software application on laptop **119**. This software application may be a native application that is used to communicate with network interface **113** and central office **106**. For example, the software application may comprise transmission manager **211**. In some embodiments, the software application, network interface **113**, and central office **106** may be configured to communicate with one another, for instance, because these elements are affiliated with an internet service provider (ISP) and/or any other type of service provider. In an illustrative example, the transmission request may comprise a download request, an upload request, or a delay-eligible upload request, as previously described.

In step **602**, a data size is determined for the transmission request. In an illustrative example, the software application that receives the transmission request may determine the size of the data that corresponds to the request. The transmission request may comprise an upload request and a software application may determine a data size for the data requested to be uploaded. In some embodiments, the software application (e.g., transmission manager **211**) may further determine whether the data that corresponds to the upload may be compressed. If the data can be compressed, the software application may compress the data and determine the data size to be the compressed data size. If the data cannot be compressed, the data size may be determined to be the size of the data that corresponds to the request. In some embodiments, the transmission request may comprise a download request, and the data size for the download may be received by the software application with the download request.

In step **603**, a transmission request that includes the determined data size may be sent. For example, the request may be sent from a device on premises **104***a*, such as laptop **119**, to central office **106** via network interface **113** and over network links **101** and **103**. In some embodiments, the request may be sent by a software application on laptop **119** that is configured to communicate with network interface **113** and central office **106** (e.g., transmission manager **211**).

In step **604**, a message is received in response to the transmission request that includes instructions about the transmission. The message may be sent from central office **106** (e.g., by scheduler **201**), received by laptop **119** on premises **104***a*, and routed to a software application on laptop **119** configured to communicate with network interface **113** and central office **106** (e.g., transmission manager **211**). In some embodiments, server **110** at central office **106** determines a schedule for a transmission corresponding to the request, as discussed above, and transmits a message to premises **104***a* that includes instructions indicating a schedule for the transmission. For example, the instructions may indicate a scheduled future time for the transmission or may indicate that the transmission has been added to a queue of transmissions.

In some embodiments, the received message may include instructions about an allocated bandwidth for the transmission. For example, the transmission may comprise a download transmission and the allocated bandwidth for the download transmission may be less than the default bandwidth for a download transmission. In another example, the transmission may comprise an upload transmission and the allocated bandwidth for the upload transmission may be less than the default bandwidth for an upload transmission.

In step **605**, it is determined that the transmission will be delayed. For example, the message received at laptop **119** may include instructions that the transmission has been scheduled for a future time or has been added to a queue of transmissions.

In step **606**, the instructions received in the message about the transmission are forwarded. In some embodiments, the transmission may comprise an upload transmission, and laptop **119** may forward the data to be uploaded and instructions for the upload transmission to one of set top box **117**, modem **114**, gateway **115**, or any other element of network interface **113**. The element that receives the data and instructions may be configured to perform the transmission. For example, the element may include software configured to communicate with central office **106**. A software application on laptop **119** configured to communicate with one or more of these elements (e.g., set top box **117**, modem **114**, gateway **115**, etc.) may forward the data and instructions. In some embodiments, the instructions may include an address for the data to be uploaded (e.g., network address where the data is to be uploaded) and/or an allocated bandwidth for the upload transmission. The instructions may also indicate a scheduling for the upload transmission (e.g., a scheduled future time for the upload transmission or an indication that the upload transmission has been queued).

In some embodiments, the transmission may comprise a download transmission. For example, laptop **119** may forward instructions for the download transmission to one of set top box **117**, modem **114**, gateway **115**, or any other element of network interface **113**. The element that receives the instructions may be configured to perform the transmission. In some embodiments, the instructions may include an address for the data to be downloaded (e.g., network address where the data is to be downloaded) and/or an allocated bandwidth for the download transmission. The instructions may also indicate a scheduling for the download transmission (e.g., a scheduled future time for the download transmission or an indication that the download transmission has been queued).

In some embodiments, when the instructions received about the transmission are forwarded, contact information is sent. For example, laptop **119** may forward instructions and, in some embodiments data, to a network element (e.g., set top box **117**, modem **114**, gateway **115**, or any other suitable network element) and laptop **119** may also send contact information for the network element that receives the instructions to central office **106** (e.g., server **110**, TS **107**). The contact information may uniquely identify an address for the network element (e.g., IP address, MAC address, etc.). In some embodiments, the contact information is sent in a message that includes an indication that the network element identified by the contact information will perform the transmission. For example, the message may indicate that further messages about the transmission are to be sent to the network element identified by the contact information.

In some embodiments, once the instructions are forwarded, the forwarding device may disconnect for the network. For example, laptop **119** may forward instructions about a transmission to a network element on a network, where the network comprises laptop **119**, modem **114**, and the receiving network element. Once the instructions are forwarded, laptop **119** may disconnect from the network and the receiving network element may complete the transmission. In some embodiments, the steps **601**-**606** of FIG. **6** are performed by transmission manager **211**.

FIG. **7** illustrates an embodiment of a process of transmitting a scheduled transmission. Any of set top box **117**, modem **114**, gateway **115**, or any other element of network interface **113** may perform the process of FIG. **7**. In some embodiments, the element or elements performing the process of FIG. **7** are configured to communicate with interface network **113** and central office **106**, for instance, because these ele-

ments are all affiliated with an internet service provider (ISP) and/or any other type of service provider. For example, the element or elements performing the process of FIG. **7** may include transmission manager **211**. In some embodiments, the element or elements may be coupled to a modem (e.g., modem **114**).

The process of FIG. **7** may begin at step **701** with data being received corresponding to a transmission and instructions being received about the transmission. In some embodiments, the data and instructions may be sent from a premises device (e.g., laptop **119**) coupled to the receiving network element. The transmission may comprise an upload transmission and the instructions may include a schedule for the upload transmission, an address (e.g., network address) for the upload transmission, and the data to be uploaded. In some embodiments, the transmission may be a download transmission and instructions may include a schedule for the download transmission and an address (e.g., network address) for the download transmission.

In some embodiments, the received instructions may include instructions about an allocated bandwidth for the transmission. For example, the transmission may comprise a download transmission and the allocated bandwidth for the download transmission may be less than the default bandwidth for a download transmission. In another example, the transmission may comprise an upload transmission and the allocated bandwidth for the upload transmission may be less than the default bandwidth for an upload transmission.

In some embodiments, the transmission is stored in a local queue of pending transmission. For example, a software application (e.g., transmission manager **211**) may receive the data corresponding to the transmission and the instructions about the transmission, and the application may queue the transmission in a local transmission queue (e.g., queue **212**). The local queue may store the transmission as a pointer to the transmission or as physical data that represents the transmission.

In step **702**, the data is transmitted according to the instructions. In some embodiments, the instructions may indicate that the transmission is scheduled for a future time. Accordingly, the process may wait until the scheduled time to begin the transmission. In some embodiments, the process may begin transmitting when it is detected that the scheduled time for the transmission is occurring, has occurred, or will occur within a predetermined amount of time. In other embodiments, the process may be required to wait for a granting message (e.g., sent from central office **106**) in order to begin transmitting. In some embodiments, a message may be received from central office **106** with new instructions that indicate a new scheduled time for the transmission. The process may then wait until the new scheduled time to begin the transmission.

In some embodiments, the instructions may indicate that the transmission has been added to a queue of transmissions (e.g., queue **207**, queue **202**). In this example, the process may wait for a message (e.g., a granting message) that indicates the transmission has reached a point in the queue where the transmission may begin. In an example, this message (e.g., granting message) may be sent from central office **106** (e.g., server **110**, TS **107**, scheduler **201**). In some embodiments, once the transmission begins transmitting, the transmission may be removed from the local queue (e.g., queue **212**).

In step **703**, the transmission may be paused. For example, a pause message may be received that includes instructions to pause the transmission. In this example, the message may be sent from central office **106** (e.g., server **110**, TS **107**). In some embodiments, the pause message includes a rescheduled time for the transmission.

In step **704**, the transmission may be resumed. In some embodiments, the transmission may be resumed after receiving a resume message. The resume message may be sent from central office **106**. In some embodiments, the transmission may be resumed according to instructions in the pause message that indicate a rescheduled time for the transmission. In this example, the transmission may be resumed at the rescheduled time without receiving a resume message. In some embodiments, steps **701-704** of FIG. **7** are performed by transmission manager **211**.

In some embodiments, the transmission may be a download, and once the download is completed, the downloaded data is retrieved by the client/terminal that requested the download. For example, the download may have been requested by laptop **119**, and laptop **119** may have forwarded instructions to complete the download to network interface **113**. Network interface **113** may then complete the download and laptop **119** may retrieve the downloaded data from network interface **113**. In some embodiments, network interface **113** sends a message to laptop **119** when the download is completed.

In some embodiments, the transmission request is generated at wireless device **120**. For example, wireless device **120** may generate the request while disconnected from a home network. A software application on wireless device **120** (e.g., transmission manager **211**) may receive the transmission request and may further detect that wireless device **120** is not connected to the home network. The software application may wait until wireless device **120** connects to the home network to send the transmission request. For instance, the software application may wait until wireless device **120** is connected to the home network to perform step **603** of FIG. **6**.

FIG. **8** illustrates hardware elements that can be used to implement any of the various computing devices discussed herein. For example, a device such as computing device **800** may be used to implement server **108**, server **109**, server **110**, terminal system **107**, network interface **113**, gateway **115**, set top box **117**, personal computer **118**, laptop computer **119** or wireless device **120**. The computing device **800** may include one or more processors **801**, which may execute instructions of a computer program to perform any of the features described herein. The instructions may be stored in a computer-readable medium or memory, to configure the operation of the processor(s) **801**. For example, instructions may be stored in a read-only memory (ROM) **802**, random access memory (RAM) **803**, removable media **804**, such as a Universal Serial Bus (USB) drive, compact disk (CD) or digital versatile disk (DVD), floppy disk drive, or other removable storage medium. Instructions may also be stored in an attached (or internal) hard drive **805**. The computing device **800** may include one or more output devices, such as a display **806** (e.g., an external television), and may include one or more output device controllers **807**, such as a video processor. There may also be one or more user input devices **808**, such as a remote control, keyboard, mouse, touch screen, microphone, etc. The computing device **800** may also include one or more network interfaces, such as a network input/output (I/O) circuit **809** (e.g., a network card, wireless transceiver, etc.) to communicate with an external network **810**. The network input/output circuit **809** may be a wired interface, wireless interface, or a combination of the two. In some embodiments, the network input/output circuit **809** may include a modem (e.g., a cable modem), and the external network **810** may include the communication links **101-103**, the external

network **112**, an in-home network, a wireless, coaxial, fiber, or hybrid fiber/coaxial distribution system (e.g., a DOCSIS network), or other network.

The FIG. **8** hardware configuration is one example. Modifications may be made to add, remove, combine, divide, etc. components of the computing device **800** into different arrangements. Additionally, the same components (e.g., processor **801**, ROM storage **802**, display **806**, etc.) may be used to implement any of the other computing devices and components described herein. For example, the various components herein may be implemented using computing devices having components such as a processor executing computer-executable instructions stored on a computer-readable medium, as illustrated in FIG. **8**. Some or all of the components described herein may be a combination of hardware and software, and may co-exist in a common physical platform (e.g., a requesting entity can be a separate software process and program from the requesting entity, both of which may be executed as software on a common computing device).

One or more aspects of the disclosure may be embodied in computer-usable data and/or computer-executable instructions, such as in one or more program modules, executed by one or more computers or other devices. Program modules may include routines, programs, objects, components, data structures, etc. that perform particular tasks or implement particular data types when executed by a processor in a computer or other data processing device. The computer executable instructions may be stored on one or more computer readable media such as a hard disk, optical disk, removable storage media, solid state memory, RAM, etc. In various embodiments, the functionality of the program modules may be combined or distributed across multiple computing devices. In addition, the functionality over the various embodiments described herein may be embodied in whole or in part in firmware or hardware equivalents such as integrated circuits, field programmable gate arrays (FPGA), and the like.

Although example embodiments are described above, the various features and steps may be combined, divided, omitted, and/or augmented in any desired manner, depending on the specific outcome and/or application. Various alterations, modifications, and improvements will readily occur to those skilled in art. Such alterations, modifications, and improvements as are made obvious by this disclosure are intended to be part of this description though not expressly stated herein, and are intended to be within the spirit and scope of the disclosure. Accordingly, the foregoing description is by way of example only, and not limiting. This patent is limited only as defined in the following claims and equivalents thereto.

We claim:

1. A method, comprising:

monitoring a traffic level on a network, the network comprising a plurality of network branches and a plurality of terminals;

receiving a transmission request from a terminal of the plurality of terminals, the transmission request comprising a data size;

scheduling a transmission for the transmission request based on the monitored traffic level and the data size, the transmission being scheduled for a future time when an estimated traffic level is less than the monitored traffic level;

adding the transmission to a transmission queue assigned to a network branch of the plurality of network branches, the network branch comprising the terminal, the transmission queue configured to queue transmissions for the terminal; and

sending a message in response to the transmission request, the message indicating a schedule for the transmission.

2. The method of claim **1**, further comprising:

determining a queue position for the transmission in the transmission queue based on at least one of the data size, the monitored traffic level, and an estimated transmission duration for the transmission.

3. The method of claim **1**, wherein the estimated traffic level for the future time is based on historical trends for at least one of a time of day for the future time, a day of week for the future time, whether the future time occurs on a weekday, whether the future time occurs on a weekend, and whether the future time occurs on a holiday.

4. The method of claim **1**, further comprising:

granting the transmission;

continuing to monitor the traffic level on the network after granting the transmission; and

pausing the granted transmission based on the continually monitored traffic level.

5. The method of claim **4**, wherein pausing the granted transmission is based on at least one of the continually monitored traffic level exceeding a first threshold and an estimated transmission duration for the granted transmission exceeding a second threshold.

6. The method of claim **4**, further comprising:

marking the paused transmission as partially completed; and

resuming the paused transmission.

7. The method of claim **6**, wherein resuming the paused transmission is based on at least one of the continually monitored traffic level being below a first threshold and an estimated transmission duration for the paused transmission being below a second threshold.

8. The method of claim **1**, wherein the transmission request is received from a software application that indicates the transmission request is a delay-eligible upload request.

9. The method of claim **1**, wherein the transmission request comprises a request for an upload and the message further indicates a bandwidth for the transmission that is less than a default bandwidth for the upload.

10. A method comprising:

sending, by a first computing device, a transmission request for compressed data, the request comprising a data size of the compressed data, the transmission request comprising an upload request for uploading the compressed data from the first computing device to a second computing device different from the first computing device;

receiving, by the first computing device, a message that comprises instructions indicating a schedule for a transmission corresponding to the transmission request;

transmitting, by the first computing device, instructions about the transmission to the second computing device, the instructions about the transmission comprising a bandwidth for the uploading of the compressed data that is less than a default bandwidth; and

transmitting the compressed data to the second computing device in accordance with the instructions.

11. The method of claim **10**, further comprising:

sending, to the second computing device, a pause message instructing the second computing device to pause the transmission; and

sending, to the second computing device, a resume message instructing the second computing device to resume the transmission.

12. The method of claim 10,

Wherein the first computing device comprises one of a desktop, laptop, smartphone, and tablet, and

wherein the second computing device comprises one of a digital video recorder (DVR) coupled to a modem, a set top box coupled to a modem, and a storage device coupled to a modem.

13. The method of claim 10, wherein the instructions about the transmission to the second computing device comprise a network location through which the compressed data is to be uploaded.

14. One or more non-transitory computer-readable media storing instructions that, when executed by a processor, cause a system to:

monitor a traffic level on a network, the network comprising a plurality of network branches and terminals;

receive a transmission request from a terminal of the plurality of terminals, the transmission request comprising a data size;

calculate an estimated duration for a transmission corresponding to the transmission request based on the monitored traffic level and the data size;

schedule the transmission based on the estimated duration, the transmission being scheduled for a future time when a future estimated duration is less than the estimated duration;

add the transmission to a transmission queue assigned to a network branch of the plurality of network branches, the network branch comprising the terminal, the transmission queue configured to queue transmissions for the terminal; and

send a message in response to the transmission request, the message indicating a schedule for the transmission.

15. The one or more non-transitory computer-readable media of claim 14, storing instructions that, when executed by the processor, cause the system to:

determine a queue position for the transmission in the transmission queue based on at least one of the data size, the monitored traffic level, and the estimated duration.

16. The one or more non-transitory computer-readable media of claim 14, wherein the future estimated duration is based on historical trends for at least one of a time of day for the future time, a day of week for the future time, whether the future time occurs on a weekday, whether the future time occurs on a weekend, and whether the future time occurs on a holiday.

17. The one or more non-transitory computer-readable media of claim 14, storing instructions that, when executed by the processor, cause the system to:

grant the transmission;

continue to monitor the traffic level on the network after granting the transmission; and

pause the granted transmission based on the continually monitored traffic level.

18. The one or more non-transitory computer-readable media of claim 17, wherein pausing the granted transmission is based on at least one of the continually monitored traffic level exceeding a first threshold and an estimated duration for the granted transmission exceeding a second threshold.

19. The method of claim 1, comprising:

determining that a current available bandwidth is insufficient for the transmission; and

determining that an estimated bandwidth at the future time is sufficient for the transmission,

wherein the transmission being scheduled for the future time is based on the estimated bandwidth at the future time being sufficient for the transmission.

20. The method of claim 1, comprising:

determining that an estimated bandwidth for the future time is greater than a current available bandwidth,

wherein the transmission being scheduled for the future time is based on the estimated bandwidth for the future time being greater than the current available bandwidth.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 9,106,557 B2
APPLICATION NO. : 13/798531
DATED : August 11, 2015
INVENTOR(S) : Wolcott et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Claims

Column 18, Claim 10, Line 45:
After “the”, insert --transmission--

Column 18, Claim 10, Line 46:
After “data,”, insert --and--

Column 19, Claim 12, Line 2:
Delete “Wherein” and insert --wherein--

Signed and Sealed this
Twenty-fifth Day of June, 2024

Katherine Kelly Vidal

Katherine Kelly Vidal
Director of the United States Patent and Trademark Office